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Design of an Experimental Facility for Particle-Turbulence Interaction

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Introduction

This project aims to design an experimental facility for studying interactions of particles and turbulent structures in air. Previous research on particle-turbulence interaction studies the phenomena of preferential particle concentrations on areas of high shear and low vorticity [1]. The research utilizing this facility will investigate effect of geometry on particle-turbulence interaction and concentrations. Particle-turbulence interactions is a topic of interest for applications such as improving combustion engine efficiency and improving heat transfer in concentrated solar power systems.

Objectives

- Design a closed circulating vertical channel with a fully developed, turbulent channel flow
- Design a flow conditioning system for homogenous mixing of particles in channel
- Design facility for interchangeability of components for future work
- Design built-in transparent access windows on the channel for laser-based flow diagnostics such as Particle Image Velocimetry (PIV) [2]

Methods

- Identifying design requirements, initial designs
- Three-dimensional modelling with computer-aided design (CAD) software SolidWorks
- Selecting material and hardware components
- Fabricating parts with the College of Science and Engineering Machine Shop
- Assembling experimental facility

Results

Figure 1. **CAD design of experimental facility (left) and completed assembly (right).**

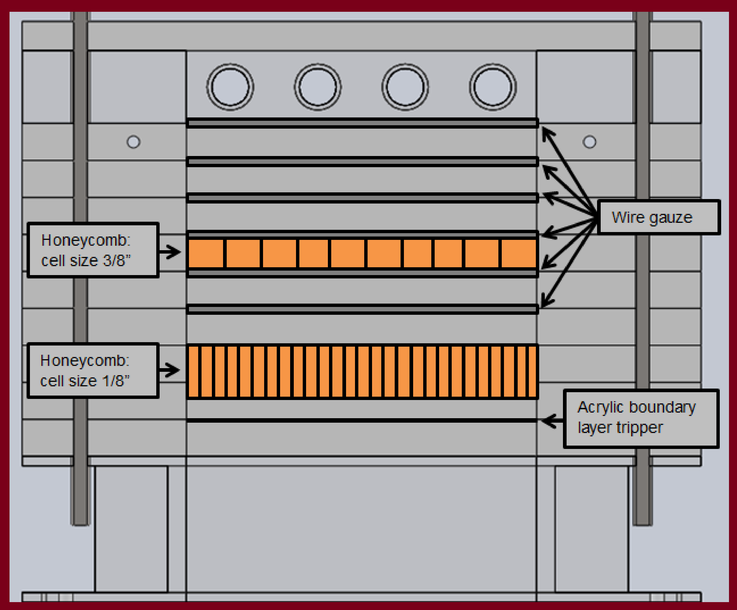

Figure 2. **Design of flow conditioning system for homogeneous mixing of particles [3]. Flow conditioner is placed on top of the channel.**

Conclusions

The closed-circulating vertical channel is designed, fabricated and assembled with the following characteristics as below:

Channel cross section (m)	0.03 x 0.24
Channel height (m)	1.9
Max. velocity at test section (m/s)	10.0
Max. Mass Flow Rate (m^3/s)	7.2×10^{-2}
Max. Reynolds Number	3.5×10^4

Table 1. **Specifications of the closed-circulating vertical channel.**

Future Work

- 2nd stage: Conducting planar PIV on particle-laden flows with spherical particles of 30-100μm.
- 3rd Stage: Conducting tomographic (3D) PIV on fiber and disk particles of length scales of 30-100μm.

The facility is designed to be compatible with the aforementioned future plans. The modular nature of the facility also allows for modifications if desired.

References

[1] Paris, A. D. *Turbulence attenuation in a particle-laden channel flow.* Diss. Stanford University, 2001.
[2] Raffel, Markus. *Particle image velocimetry: a practical guide*. Springer, 2007.
[3] Khalitov, Daniel. *Gas-particle Interaction in Turbulent Channel Flow*. Diss. University of Minnesota, 2004.

Acknowledgements

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